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(54) **FIXING APPARATUS THAT CONTROLS CURRENT FOR DRIVING AN INDUCTION HEATER**

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(58) **Field of Classification Search**
CPC G03G 15/2016; G03G 15/2053; G03G 15/2078; G03G 2215/2016
See application file for complete search history.

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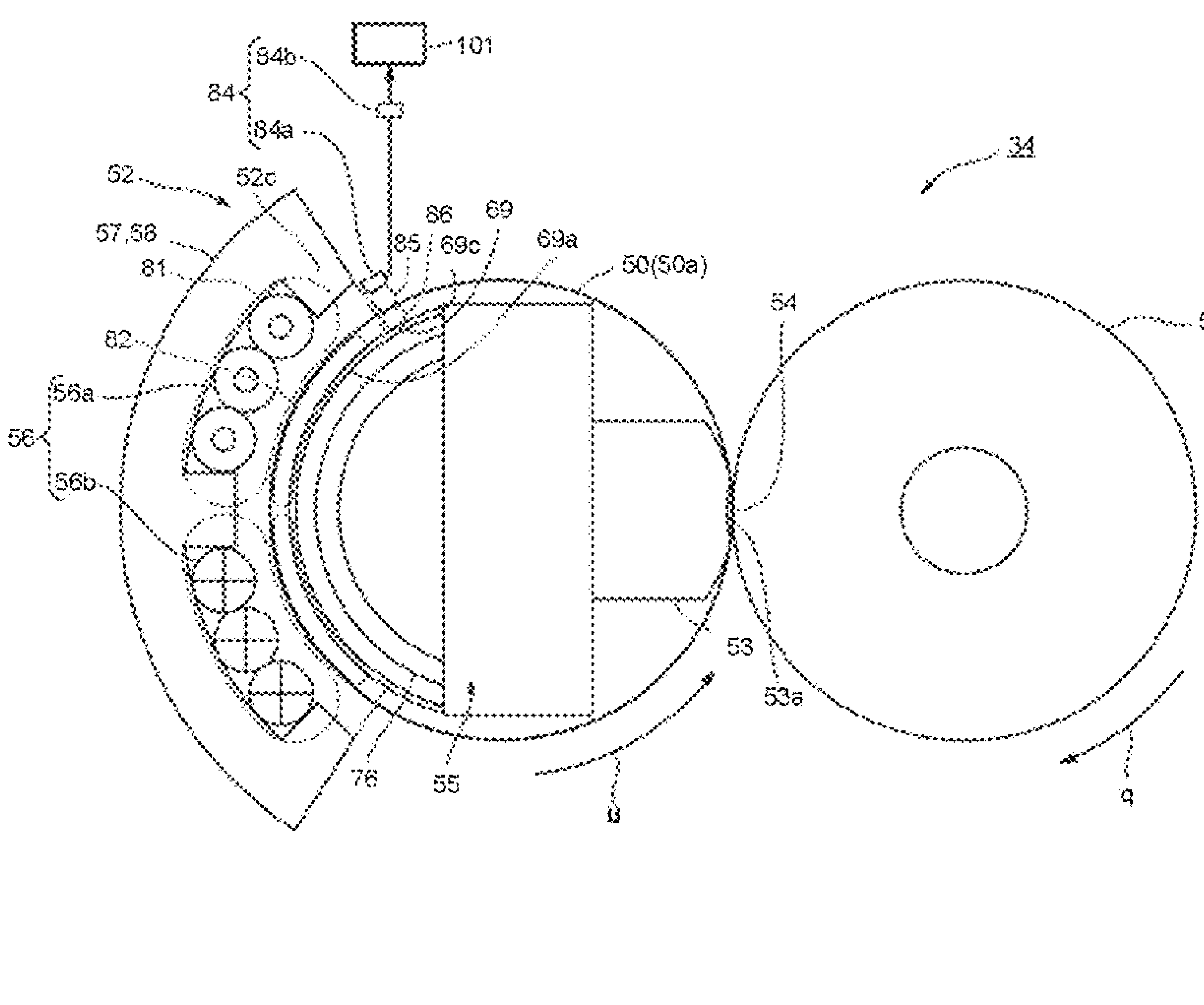
(57) **ABSTRACT**

A fixing apparatus includes a belt including a ferromagnetic layer. A ferromagnetic plate is disposed inside the belt and has a Curie point that is lower than a Curie point of the ferromagnetic layer. An induction heater causes heat generation in the ferromagnetic layer and the ferromagnetic plate. The induction heater includes a coil. A driving circuit outputs a high frequency current to the coil, and changes the high frequency current. A temperature sensor measures a temperature of the coil. A controller controls the driving circuit to decrease the high frequency current if the temperature of the coil measured by the temperature sensor is higher than a predetermined value.

10 Claims, 9 Drawing Sheets



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2014/0314457	A1	10/2014	Kikuchi	
2015/0168888	A1	6/2015	Kikuchi	

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FIG.1

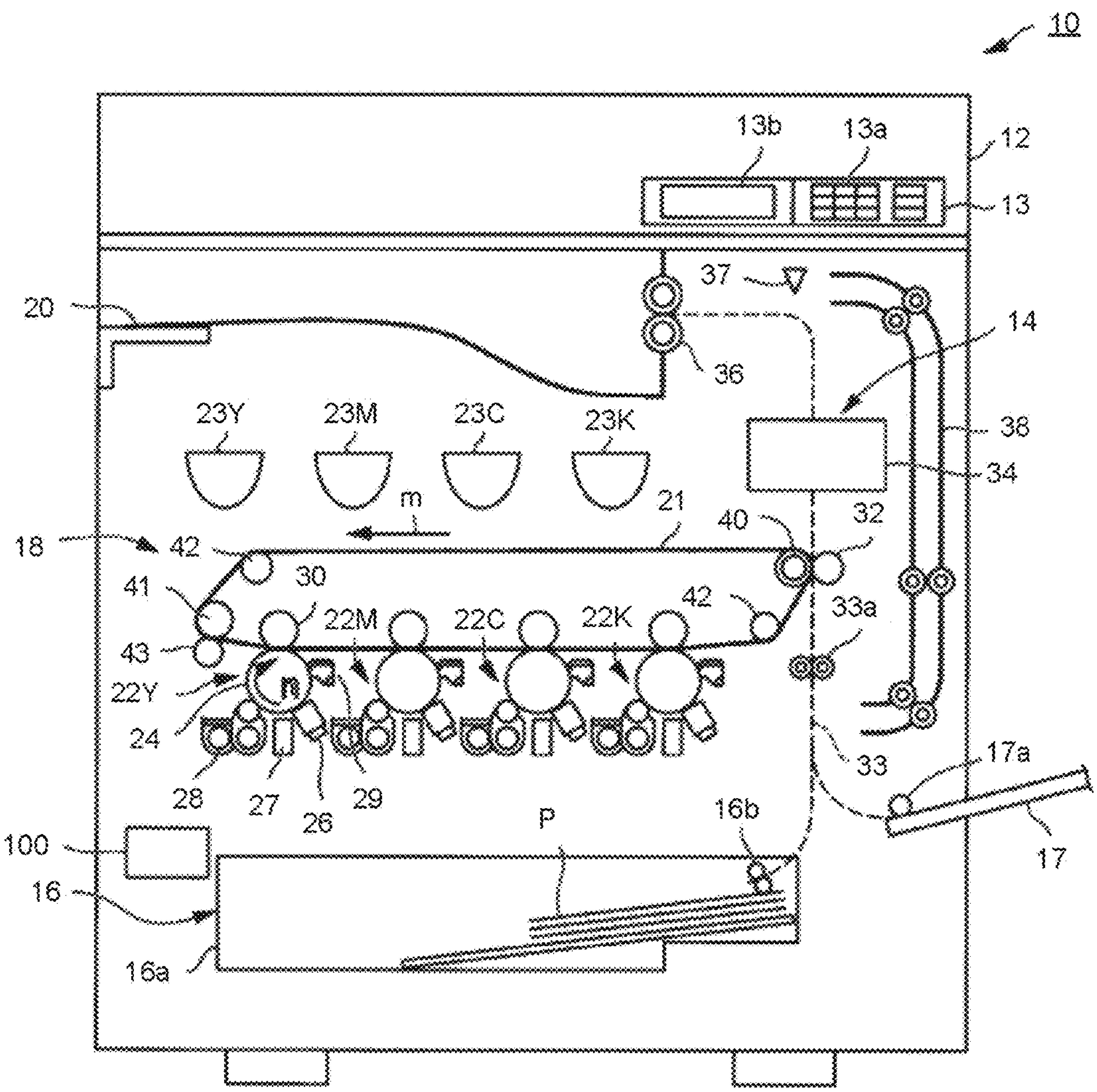

10
13b
13a
12
13
20
37
14
36
38
23Y
23M
23C
23K
34
m
21
40
32
18
42
30
41
22M
22C
22K
42
33a
43
22Y
n
24
33
28
27
26
29
17a
P
16b
100
17
16
16a

FIG.2

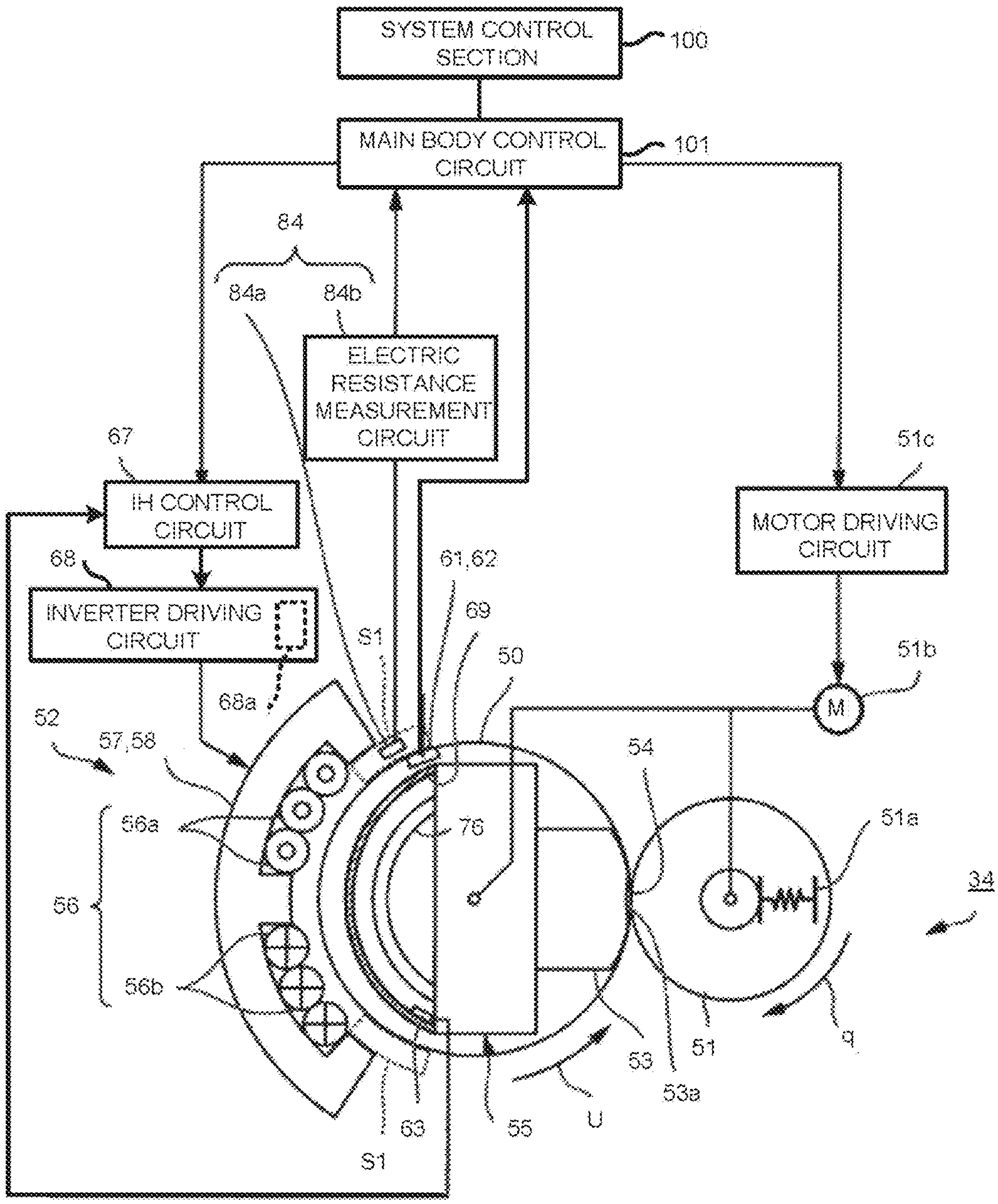

SYSTEM CONTROL SECTION
100
MAIN BODY CONTROL CIRCUIT
101
84
84a
84b
ELECTRIC RESISTANCE MEASUREMENT CIRCUIT
67
IH CONTROL CIRCUIT
51c
MOTOR DRIVING CIRCUIT
68
INVERTER DRIVING CIRCUIT
61,62
69
S1
50
51b
M
68a
52
57,58
54
51a
76
56a
56
34
56b
53
51
q
53a
63
55
U
S1

FIG.3

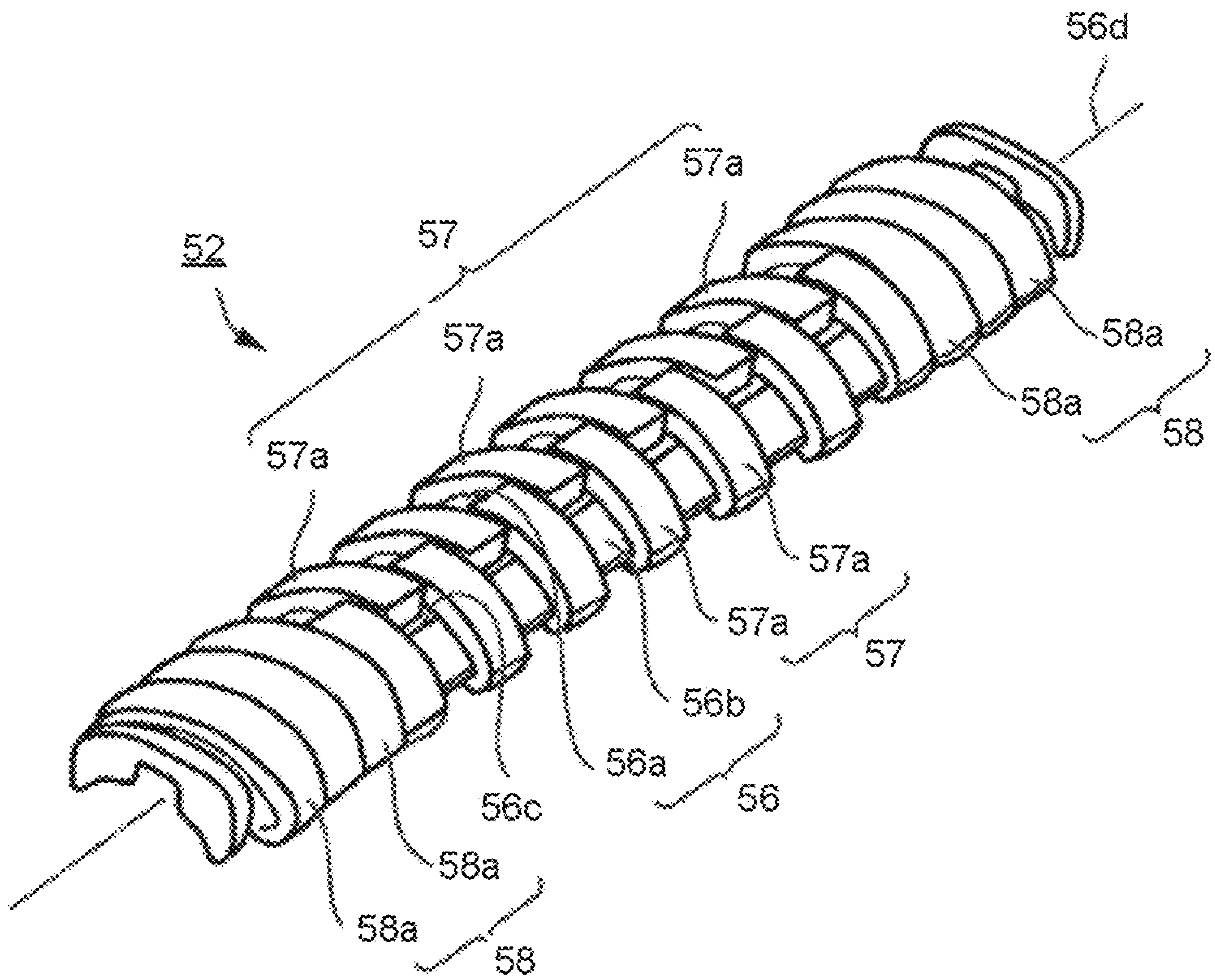
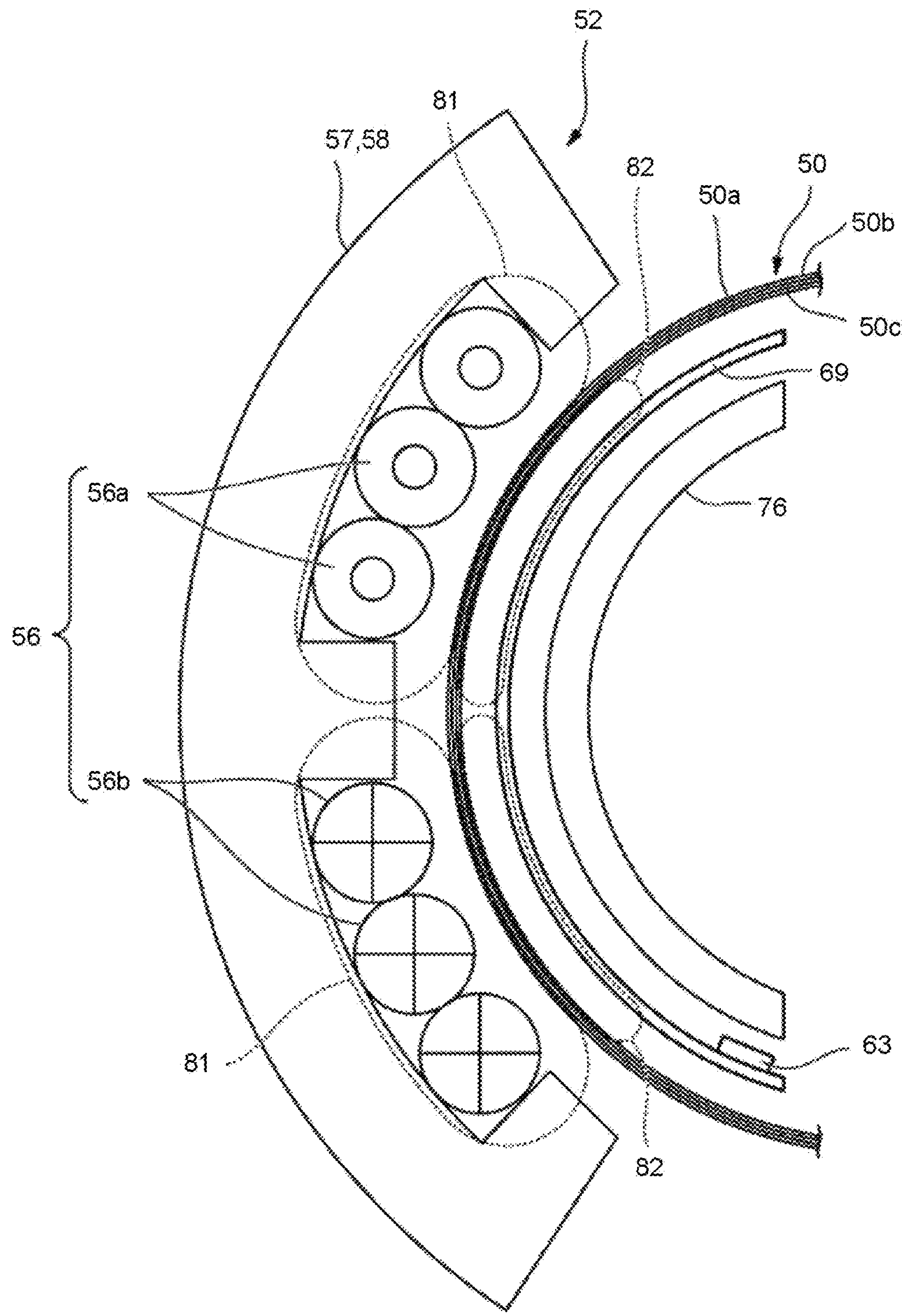

56d
57a
57
52
57a
57a
58a
58a
58
57a
57a
57
56b
56a
56
56c
58a
58a
58

FIG.4



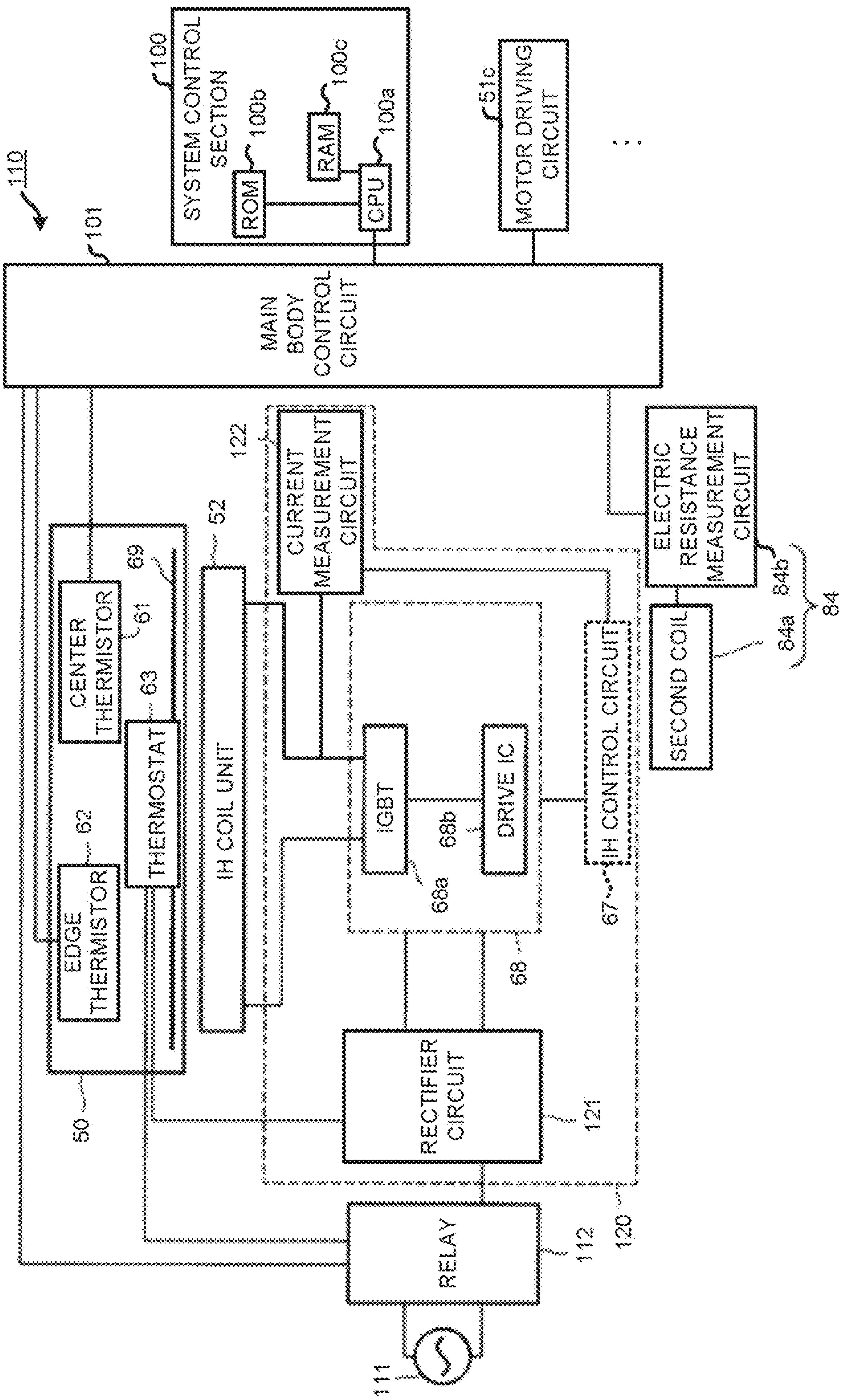

110
101
MAIN BODY CONTROL CIRCUIT
100
SYSTEM CONTROL SECTION
100b
ROM
100c
RAM
100a
CPU
51c
MOTOR DRIVING CIRCUIT
...
50
CENTER THERMISTOR
61
69
63
THERMOSTAT
62
EDGE THERMISTOR
52
IH COIL UNIT
122
CURRENT MEASUREMENT CIRCUIT
IGBT
68a
68b
DRIVE IC
68
67
IH CONTROL CIRCUIT
ELECTRIC RESISTANCE MEASUREMENT CIRCUIT
84b
SECOND COIL
84a
84
RECTIFIER CIRCUIT
121
RELAY
112
120
111

FIG.5

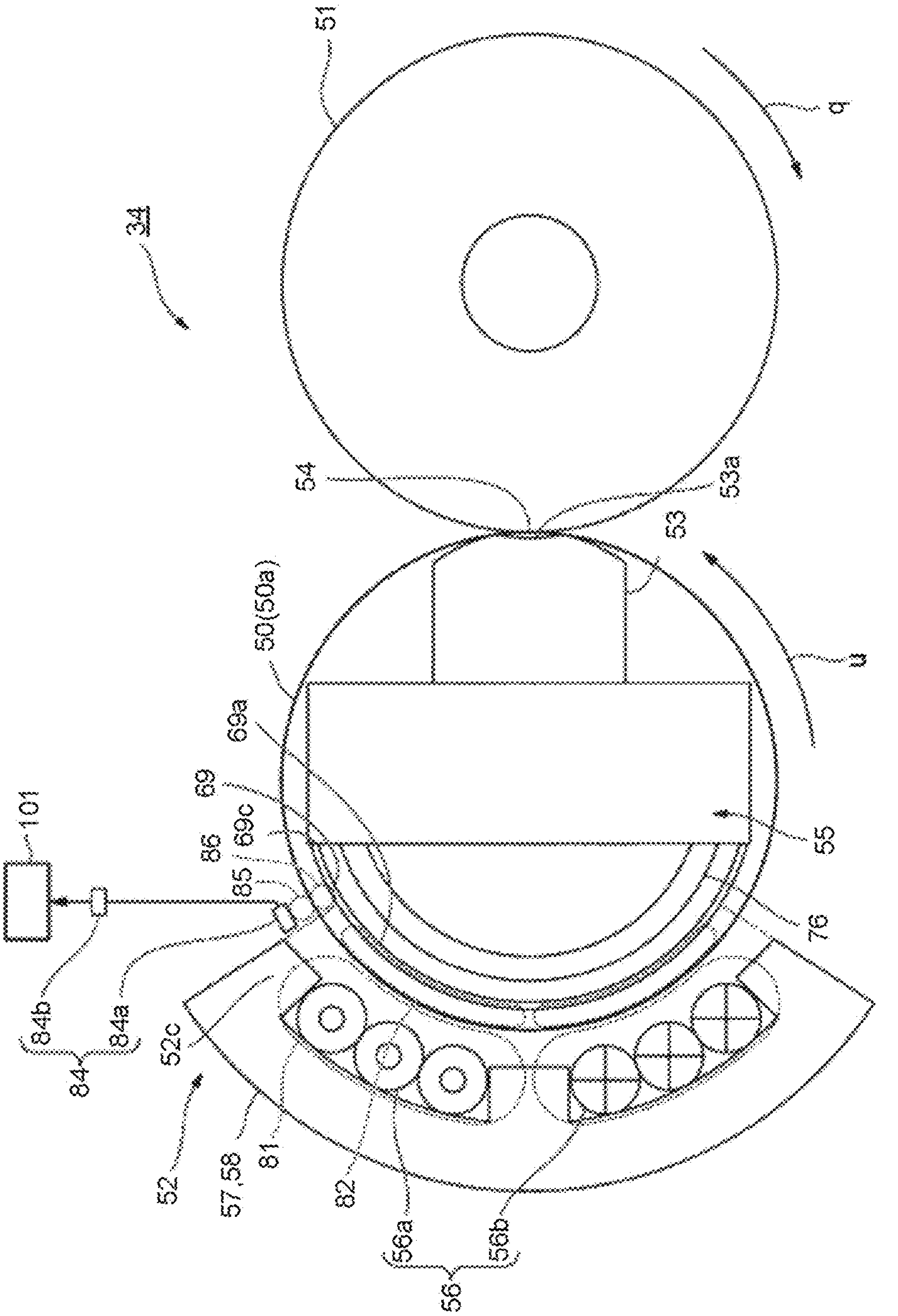
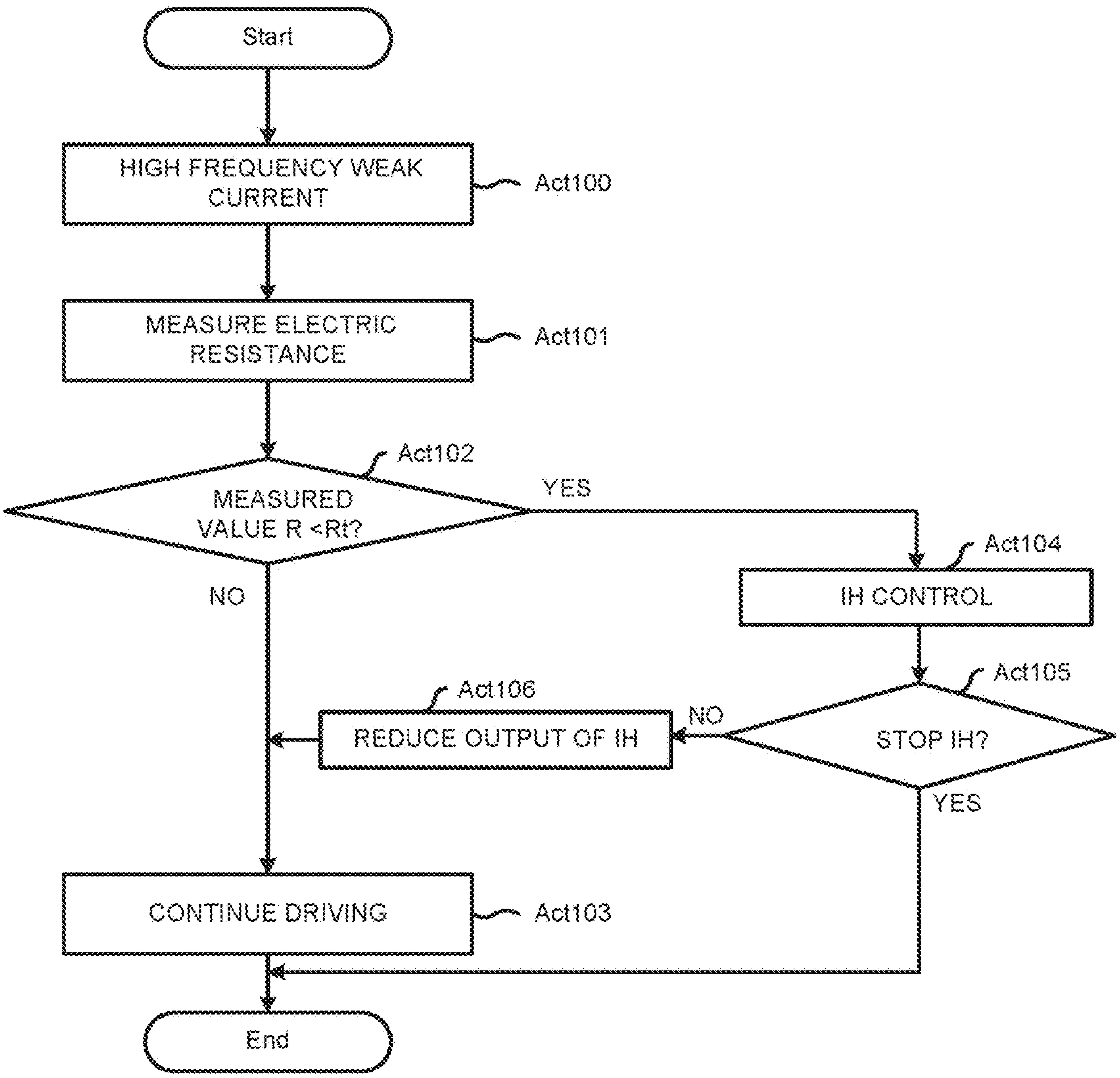

51
q
34
54
53a
53
50(50a)
u
69a
69
101
86
69c
85
55
76
84b
84a
84
52c
52
57,58
81
82
56a
56b
56

FIG.6

FIG.7


Start
HIGH FREQUENCY WEAK CURRENT
Act100
MEASURE ELECTRIC RESISTANCE
Act101
Act102
MEASURED VALUE R <Rt?
YES
NO
Act104
IH CONTROL
Act105
STOP IH?
NO
YES
Act106
REDUCE OUTPUT OF IH
CONTINUE DRIVING
Act103
End

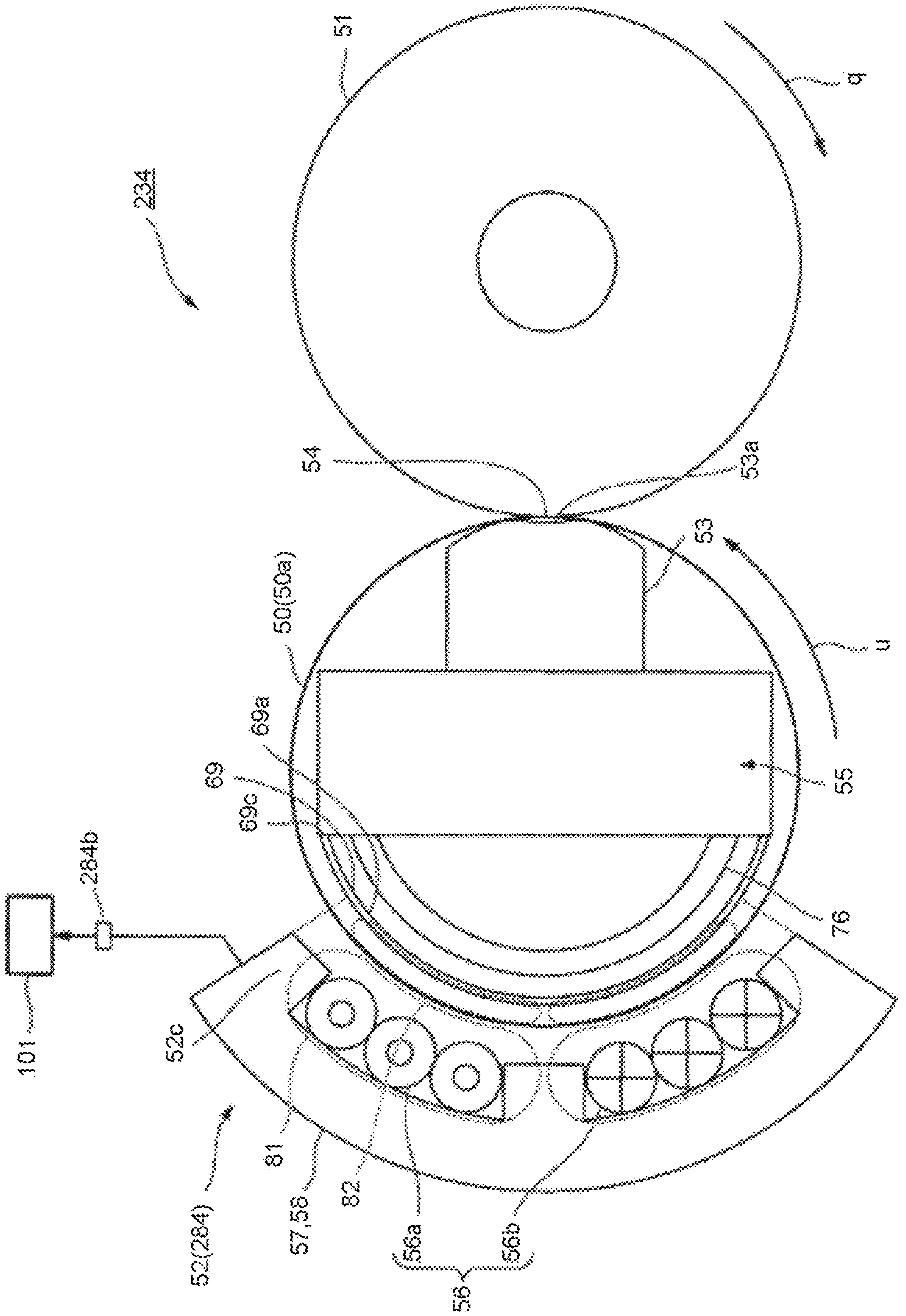
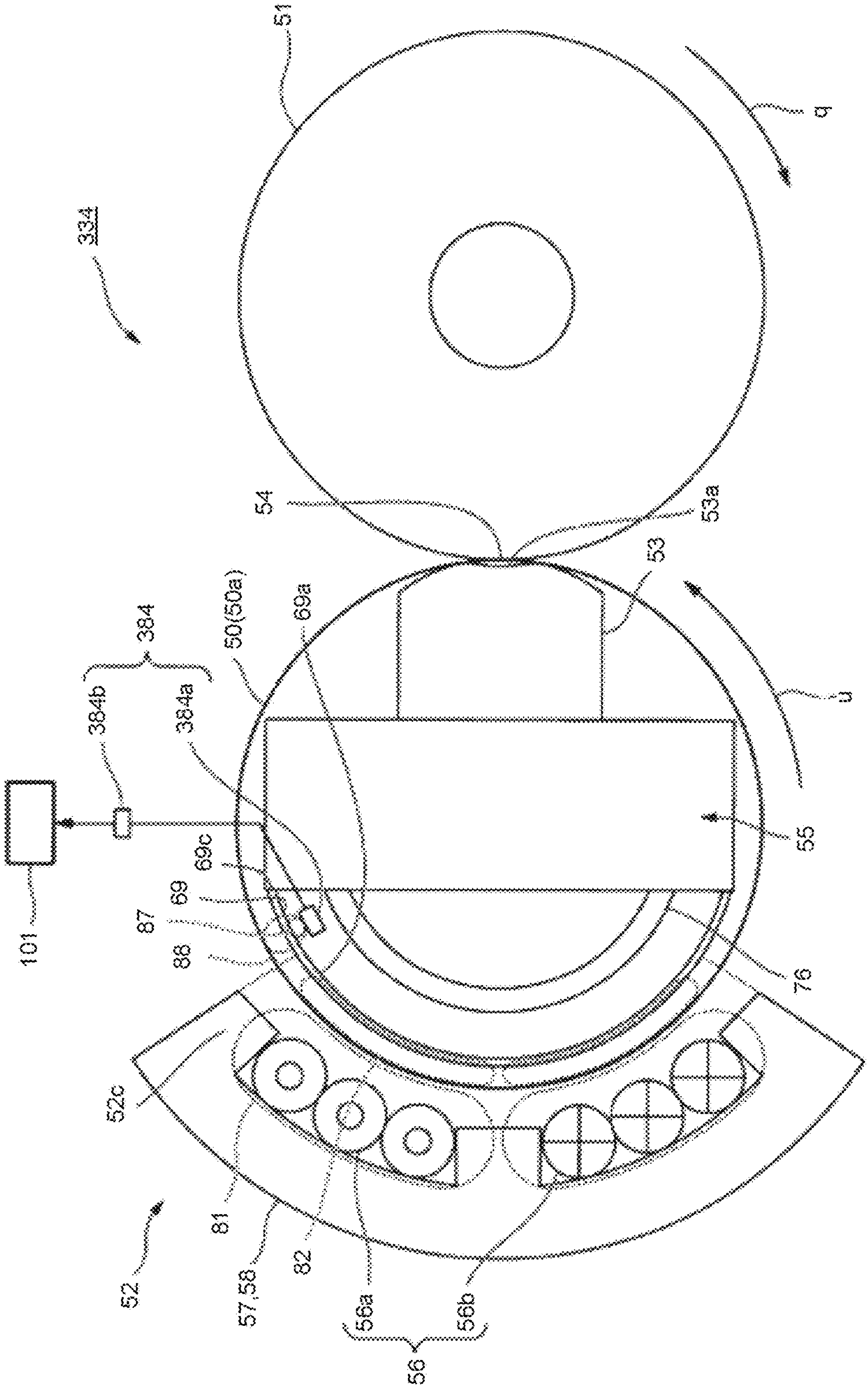

234
51
q
54
53a
53
50(50a)
u
69a
69
69c
55
284b
76
101
52c
81
57,58
82
56a
56b
56
52(284)

FIG.8



51
q
334
54
53a
53
50(50a)
69a
384
384b
384a
55
u
101
69c
69
87
88
76
52c
81
82
57,58
52
56a
56b
56

FIG.9

FIXING APPARATUS THAT CONTROLS CURRENT FOR DRIVING AN INDUCTION HEATER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of U.S. patent application Ser. No. 14/927,207, filed on Oct. 29, 2015, which is based upon and claims the benefit of priorities from Japanese Patent Application No. 2014-240105, filed on Nov. 27, 2014 and Japanese Patent Application No. 2015-118445, filed on Jun. 11, 2015; the entire contents of each of the applications are incorporated herein by reference.

FIELD

Embodiments described herein relate to a fixing apparatus, in particular, a fixing apparatus that controls the current for driving an induction heater.

BACKGROUND

An image forming apparatus such as a Multi-functional Peripheral (hereinafter referred to as "MFP"), a printer, and the like typically includes a fixing apparatus. The fixing apparatus of one type causes heat generation for the fixing by an electromagnetic induction heating unit (hereinafter referred to as an "IH" unit). A fixing apparatus that includes the IH unit includes a fixing belt and an auxiliary heating unit that generate heat. The IH unit is usually configured to maintain its output level to maintain a certain amount of heat generation. For example, when the auxiliary heating unit loses its magnetism as the temperature thereof increases too much, electric resistance of the IH unit decreases. In this case, to maintain the output level, level of a current supplied from a driving circuit to the IH unit is increased. However, this increase of the current level may damage the driving circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of an image forming apparatus according to a first embodiment.

FIG. **2** is a side view of an IH coil unit and illustrates a control block of a main control circuit according to the first embodiment.

FIG. **3** is a perspective view of the IH coil unit according to the first embodiment.

FIG. **4** illustrates magnetic paths of magnetic fluxes extending along a fixing belt and an auxiliary heating plate according to the first embodiment.

FIG. **5** is a block diagram of a control system, which controls the IH coil unit according to the first embodiment.

FIG. **6** is a side view of a fixing apparatus according to the first embodiment.

FIG. **7** is a flowchart illustrating an operation carried out by the fixing apparatus according to the first embodiment.

FIG. **8** is a side view of a fixing apparatus according to a second embodiment.

FIG. **9** is a side view of a fixing apparatus according to a third embodiment.

DETAILED DESCRIPTION

In accordance with an embodiment, a fixing apparatus includes a belt including a ferromagnetic layer, a roller facing the belt, a ferromagnetic plate disposed inside the belt and having a Curie point that is lower than a Curie point of the ferromagnetic layer, an induction heater configured to cause heat generation in the magnetic layer and the ferromagnetic plate, a driving circuit configured to output a high frequency current to the induction heater by switching on and off switching elements thereof, and a controller. An image on a sheet is fixed as the sheet passes through a nip formed between the belt and the roller. The controller is configured to determine whether or not a temperature of the ferromagnetic plate is higher than the Curie point thereof, and control the driving circuit to reduce a level of the high frequency current when the temperature of the ferromagnetic plate is determined to be higher than the Curie point thereof.

First Embodiment

Hereinafter an image forming apparatus **10** according to a first embodiment is described with reference to the accompanying drawings. Further, the same components are applied with same reference numerals in the drawings.

FIG. **1** is a side view of the image forming apparatus **10** according to the first embodiment. A Multi-function peripheral (MFP) is described below as an example of the image forming apparatus **10**.

As shown in FIG. **1**, the MFP **10** includes a scanner **12**, a control panel **13**, and a main body section **14**. Each of the scanner **12**, the control panel **13**, and the main body section **14** includes a control section. The MFP **10** includes a system control unit **100** serving as the control section for the scanner **12**, the control panel **13** and the main body section **14**.

The system control unit **100** includes a CPU (Central Processing Unit) **100***a*, an ROM (Read Only Memory) **100***b*, and an RAM (Random Access Memory) **100***c* (refer to FIG. **5**). The system control unit **100** controls a main control circuit **101** (refer to FIG. **2**) serving as the control section for the main body section **14**.

The main control circuit **101** includes a CPU, a ROM and a RAM (none are shown). The main body section **14** includes a paper feed cassette unit **16**, a printer unit **18**, a fixing apparatus **34**, and the like. The main control circuit **101** controls the paper feed cassette unit **16**, the printer unit **18**, the fixing apparatus **34**, and the like.

The scanner **12** reads an image of a document. The control panel **13** has input keys **13***a* and a display unit **13***b*. For example, the input keys **13***a* receive an input from a user. For example, the display unit **13***b* is of a touch panel type. The display unit **13***b* receives an input from the user and displays information to the user.

The paper feed cassette unit **16** includes a paper feed cassette **16***a* and a pickup roller **16***b*. The paper feed cassette **16***a* stores sheets P serving as media. The pickup roller **16***b* picks up the sheet P from the paper feed cassette **16***a*. The paper feed cassette **16***a* is provided to store sheets P. A paper feed tray **17** is provided to feed sheets P with a pickup roller **17***a*.

The printer unit **18** forms an image. For example, the printer unit **18** carries out image forming processing of the image of the document read by the scanner **12**. The printer unit **18** includes an intermediate transfer belt **21**. In the printer unit **18**, the intermediate transfer belt **21** is supported by a backup roller **40**, a driven roller **41**, and a tension roller **42**. The backup roller **40** includes a driving unit (not shown) and configured to rotate on its own. In the printer unit **18**, the intermediate transfer belt **21** rotates in a direction indicated by an arrow m.

The printer unit **18** further includes four sets of image forming stations **22**Y, **22**M, **22**C, and **22**K. The image forming stations **22**Y, **22**M, **22**C, and **22**K are used to respectively form a yellow (Y) image, a magenta (M) image, a cyan (C) image, and a black (K) image. The image forming stations **22**Y, **22**M, **22**C, and **22**K are arranged in parallel to each other along the rotational direction of the intermediate transfer belt **21** below the intermediate transfer belt **21**.

The printer unit **18** further includes cartridges **23**Y, **23**M, **23**C, and **23**K above the image forming stations **22**Y, **22**M, **22**C, and **22**K, respectively. The cartridges **23**Y, **23**M, **23**C, and **23**K store toner for replenishment of yellow (Y), magenta (M), cyan (C), and black (K), respectively.

Hereinafter, the image forming station **22**Y for forming a yellow (Y) image among the image forming stations **22**Y, **22**M, **22**C, and **22**K is described as an example. Further, as the configurations of the image forming stations **22**M, **22**C, and **22**K are the same as the configuration of the image forming station **22**Y, the detailed description thereof is not provided.

The image forming station **22**Y includes a charger **26**, an exposure scanning head **27**, a developing device **28**, and a photoconductive cleaner **29**. The charger **26**, the exposure scanning head **27**, the developing device **28**, and the photoconductive cleaner **29** are arranged around a photoconductive drum **24** that is configured to rotate in a direction indicated by an arrow n.

The image forming station **22**Y includes a primary transfer roller **30**. The primary transfer roller **30** faces the photoconductive drum **24** across the intermediate transfer belt **21**.

The image forming station **22**Y exposes the photoconductive drum **24** that is charged by the charger **26** through the exposure scanning head **27**. The image forming station **22**Y forms an electrostatic latent image on the photoconductive drum **24**. The developing device **28** develops the electrostatic latent image on the photoconductive drum **24** using a two-component developing agent including toner and carrier.

The primary transfer roller **30** primarily transfers the toner image formed on the photoconductive drum **24** to the intermediate transfer belt **21**. The image forming stations **22**Y, **22**M, **22**C, and **22**K form a color (full-color) toner image on the intermediate transfer belt **21** through the primary transfer rollers **30**. The color toner image is formed by overlapping toner images of Y (yellow), M (magenta), C (cyan), and K (black) in sequence. The photoconductive cleaner **29** removes the toner left on the photoconductive drum **24** after the primary transfer.

The printer unit **18** further includes a secondary transfer roller **32**. The secondary transfer roller **32** faces the backup roller **40** across the intermediate transfer belt **21**. The secondary transfer roller **32** operates to transfer the color toner image on the intermediate transfer belt **21** to the sheet P. The sheet P is fed by the paper feed cassette unit **16** or the manual paper feeding tray **17** along the conveyance path **33**.

The printer unit **18** further includes a belt cleaner **43** facing the driven roller **41** across the intermediate transfer belt **21**. The belt cleaner **43** removes toner left on the intermediate transfer belt **21** after the secondary transfer.

The printer unit **18** also includes a register roller **33***a*, a fixing apparatus **34**, and a sheet discharge roller **36**, along the conveyance path **33**. The printer unit **18** further includes a bifurcating unit **37** and a reversal conveyance unit **38** at the downstream side of the fixing apparatus **34** in a sheet conveying direction. The bifurcating unit **37** sends the sheet P subjected to fixing processing to a sheet discharge unit **20** or the reversal conveyance unit **38**. In a case of duplex printing, the reversal conveyance unit **38** reverses the sheet P sent from the bifurcating unit **37** to a direction of the register roller **33***a* and conveys the sheet P. The MFP **10** forms a fixed toner image on the sheet P with the printer unit **18** and then discharges it to the sheet discharge unit **20**.

Further, the MFP **10** is not limited to the tandem developing system, and the number of the developing devices **28** is also not limited. Further, the MFP **10** may transfer the toner image from the photoconductive drum **24** to the sheet P directly.

Hereinafter, the fixing apparatus **34** is described in detail.

FIG. **2** is a side view of the fixing apparatus **34**, including an electromagnetic induction heating coil unit **52** (induction current generation section), and illustrates a control block of a main control circuit **101** (control section) according to the first embodiment. Hereinafter, the electromagnetic induction heating coil unit is referred to as an "IH coil unit".

As shown in FIG. **2**, the fixing apparatus **34** includes a fixing belt **50**, a press roller **51**, an IH coil unit **52**, an auxiliary heating plate **69** (auxiliary heating section), a second coil unit **84** (measurement section), and the main control circuit **101**.

The fixing belt **50** is a cylindrical endless belt. In the inner peripheral space of the fixing belt **50**, an internal belt mechanism **55** including a nip pad **53** and the auxiliary heating plate **69** is arranged.

The fixing belt **50** is formed by laminating a heating layer **50***a* (conductive layer) serving as a heating unit and a releasing layer **50***c* in sequence on a base layer **50***b* (refer to FIG. **4**). Further, as long as the fixing belt **50** includes the heating layer **50***a*, no limitation is given to the layer structure.

The base layer **50***b* is made from, for example, polyimide resin (PI). The heating layer **50***a* is formed of, for example, a non-magnetic metal such as copper (Cu). The releasing layer **50***c* is made from, for example, fluorine resin such as PFA (Tetrafluoroethylene Perfluoro alkyl vinyl ether copolymer resin).

In order to rapidly warm up the fixing belt **50**, the heating layer **50***a* is thin and the heat capacity of the fixing belt **50** is low. The fixing belt **50** having low heat capacity shortens the time required to warm up the fixing belt **50** and saves energy consumption for the warming-up.

In order to reduce the heat capacity of the fixing belt **50**, the thickness of the copper layer of the heating layer **50***a* is, for example, 10 μm. Further, the heating layer **50***a* is coated by a protective layer such as nickel. The nickel protective layer can suppress the oxidation of copper layer, which can improve the mechanical strength of the fixing belt **50**.

Further, the heating layer **50***a* may be formed by performing copper plating as well as electroless nickel plating on the base layer **50***b* made from polyimide resin. By performing the electroless nickel plating, the adhesion strength of the base layer **50***b* to the heating layer **50***a* is improved, and the mechanical strength of the fixing belt **50** is also improved.

Further, the surface of the base layer **50***b* may be roughened through sandblast or chemical etching. By roughening the surface of the base layer **50***b*, the adhesion strength of the base layer **50***b* to the nickel plating of the heating layer **50***a* is further improved.

Further, a metal such as titanium (Ti) may be dispersed into the polyimide resin for forming the base layer **50***b*. By dispersing metal into the base layer **50***b*, the adhesion strength of the base layer **50***b* to the nickel plating of the heating layer **50***a* is further improved.

For example, the heating layer **50***a* may be made from nickel, iron (Fe), stainless steel, aluminum (Al), silver (Ag), or the like. The heating layer **50***a* may use two or more kinds of alloys, and may also be formed by stacking two or more kinds of metal in layer.

FIG. **3** is a perspective view of the IH coil unit **52** according to the first embodiment.

As shown in FIG. **3**, the IH coil unit **52** includes a main coil **56** (first coil), a first core **57**, and a second core **58**.

The main coil **56** generates magnetic flux in accordance with application of a high frequency current. The main coil **56** is arranged at the outer peripheral side of the fixing belt **50**. The main coil **56** faces the fixing belt **50** in the thickness direction. The longitudinal direction of the main coil **56** is parallel to the width direction of the fixing belt **50** (hereinafter referred to as a "belt width direction").

The first core **57** and the second core **58** cover a side of the main coil **56** (hereinafter referred to as "backside") that is opposite to the side that faces the fixing belt **50**. The first core **57** and the second core **58** prevent leakage of the magnetic flux generated by the main coil **56** at the back side. The first core **57** and the second core **58** concentrate the magnetic flux from the main coil **56** on the fixing belt **50**.

The first core **57** includes a plurality of single wing parts **57***a*. The plurality of single wing parts **57***a* is alternately arranged in a staggered manner with a center line **56***d* along the longitudinal direction of the main coil **56** as an axis of symmetry.

The second core **58** is arranged at both sides of the first core **57** in the longitudinal direction thereof. The second core **58** includes a plurality of dual wing parts **58***a* across both sides of the main coil **56**. For example, the single wing part **57***a* and the dual wing part **58***a* may be made from magnetic material such as a nickel-zinc alloy (Ni—Zn), a manganese-nickel alloy (Mn—Ni), and the like.

The first core **57** regulates the magnetic flux generated by the main coil **56** with the plurality of the single wing parts **57***a*. The magnetic flux generated by the main coil **56** may be regulated alternately by every single wing part **57***a* with a central line **56***d* as an axis of symmetry. The first core **57** concentrates the magnetic flux from the main coil **56** on the fixing belt **50** with the plurality of single wing parts **57***a*.

The second core **58** regulates the magnetic flux generated by the main coil **56** with the plurality of dual wing parts **58***a*. The magnetic flux generated by the main coil **56** is regulated by the dual wing parts **58***a* at both sides of the first core **57**. The second core **58** concentrates the magnetic flux from the main coil **56** on the fixing belt **50** with the plurality of dual wing parts **58***a*. The magnetic flux concentration caused by the second core **58** is greater than the magnetic flux concentration caused by the first core **57**.

The main coil **56** includes first wings **56***a* and second wings **56***b*. The first wings **56***a* are arranged at one side of the central line **56***d*. The second wings **56***b* are arranged at the other side of the central line **56***d*. Window parts **56***c* are formed between the first wings **56***a* and the second wings **56***b* at the inner side in the longitudinal direction of the main coil **56**.

For example, the main coil **56** uses litz wire. The litz wire is formed of a plurality of bundles of copper wire material that is coated by the heat-resistant polyamide-imide serving as an insulated material. The main coil **56** is formed by winding the conductive coils.

As shown in FIG. **2**, the main coil **56** generates the magnetic flux through the application of the high frequency current from the inverter driving circuit **68**. For example, the inverter driving circuit **68** includes switching elements including the IGBT (Insulated Gate Bipolar Transistor) element **68***a*, a MOSFET (Metal Oxide semiconductor field effect Transistor) element (not shown), and the like. The IGBT element **68***a* is connected to the MOSFET element. By alternately turning on/off the IGBT element **68***a* and the MOSFET element, a high frequency current flows into the main coil **56**. By the flow of the high frequency current into the main coil **56**, a high frequency magnetic field is generated around the main coil **56**. Through the magnetic flux of the high frequency magnetic field, an eddy current is generated in the heating layer **50***a* of the fixing belt **50**. Further, Joule heat is generated due to the eddy current flowing in the heating layer **50***a* that has electric resistance. As a result, the fixing belt **50** is heated.

For example, it is assumed that the "ON" period of the IGBT element **68***a* is constant. By varying the "ON" period of the MOSFET element, the high frequency current flowing into the main coil **56** changes. With the change of high frequency current flowing into the main coil **56**, the output of the electromagnetic induction heating also changes.

The auxiliary heating plate **69** is arranged at the inner peripheral side of the fixing belt **50**. Seen in a belt width direction, the auxiliary heating plate **69** has an arc shape and is arranged along the inner peripheral surface of the fixing belt **50**. The auxiliary heating plate **69** faces the main coil **56** across the fixing belt **50**. The auxiliary heating plate **69** is formed of a magnetic material (ferromagnetic material) of which the Curie point is lower than that of the heating layer **50***a*. Magnetic flux through the auxiliary heating plate **69** and the fixing belt **50** is generated by the magnetic flux generated by the main coil **56**. Consequently, Joule heat is generated in the heating layer **50***a*. The generated Joule heat is used to further heat the fixing belt **50** by the main coil **56**.

The auxiliary heating plate **69** is supported by sills (not shown) at the arc-shaped both ends thereof. The outer surface of the auxiliary heating plate **69** in the diameter direction (radial direction) is separated from the inner peripheral surface of the fixing belt **50**. For example, the length of a gap between the outer surface of the auxiliary heating plate **69** and the inner peripheral surface of the fixing belt **50** is about 1~2 mm. Alternatively, the outer surface of the auxiliary heating plate **69** may be in contact with the inner peripheral surface of the fixing belt **50**.

For example, the auxiliary heating plate **69** in the belt width direction is longer than a sheet-passing area in the belt width direction (hereinafter referred to as a "sheet width"). In addition, the sheet width is a width of a sheet of which the short-side width is longest among sheets that can be used in the MFP **10**. For example, it is assumed that the sheet width is a little longer than the short-side width of A3-sized paper.

FIG. **4** illustrates magnetic paths of the magnetic flux generated by the main coil **56** according to the first embodiment. The magnetic paths extend through the fixing belt **50** and/or the auxiliary heating plate **69**.

As shown in FIG. **4**, the magnetic flux generated by the main coil **56** forms a first magnetic path **81** extending through the heating layer **50***a* of the fixing belt **50**. The first magnetic path **81** is formed in such a manner that the first wings **56***a* and the second wings **56***b* of the main coil **56** are surrounded. The first magnetic path **81** passes through the first core **57**, the second core **58**, and the heating layer **50***a*. Further, the magnetic flux generated by the main coil **56** forms a second magnetic path **82** that extends through the auxiliary heating plate **69**. The second magnetic path **82** is formed at a position adjacent to the first magnetic path **81** in a diameter direction of the fixing belt **50** (hereinafter referred to as a "belt diameter direction"). The second magnetic path **82** passes through the auxiliary heating plate **69** and the heating layer **50***a*.

The auxiliary heating plate **69** is formed of thin metal member made from the magnetic shunt alloy such as iron or nickel alloy of which the Curie point is 220~230 degrees centigrade. When the temperature of the auxiliary heating plate **69** exceeds the Curie point thereof, the auxiliary heating plate **69** will lose its magnetism. Specifically, when the Curie point is exceeded, the magnetism of the auxiliary heating plate **69** is changed from ferromagnetism to paramagnetism. When the temperature of the auxiliary heating plate **69** exceeds the Curie point thereof, the second magnetic path **82** is not formed and consequently there is no assistance to the heat of the fixing belt **50**. By forming the auxiliary heating plate **69** with the magnetic shunt alloy, the auxiliary heating plate **69** can be used to assist the rise of temperature of the fixing belt **50** when the temperature is lower than the Curie point thereof, and can be used to prevent the excessive temperature rise of the fixing belt **50** when the temperature is higher than the Curie point thereof.

Herein, the heating of the fixing belt **50** is adjusted through electric control of an IH control circuit **67**. To keep the belt temperature constant, the output of the IH coil unit **52** is controlled to be constant. If the auxiliary heating plate **69** is formed of magnetic shunt alloy, the auxiliary heating plate **69** loses its magnetism when the temperature thereof exceeds the Curie point, and the second magnetic path **82** is not formed. Consequently, the load (electric resistance) of the IH coil unit **52** decreases.

The IH control circuit **67** increases the current flowing through the inverter driving circuit **68** corresponding to the reduction of load of the IH coil unit **52** so as to keep the output of the IH coil unit **52** constant. If the current flowing through the inverter driving circuit **68** is increased, the current flowing in the IGBT element **68***a* is also increased. If so, the temperature of the IGBT element **68***a* rises excessively, and the IGBT element **68***a* may be damaged. To prevent this, in the present embodiment, the change of magnetism of the auxiliary heating plate **69** is estimated by measuring the electric resistance of the second coil **84***a*. In addition, the IH control circuit **67** controls the IH coil unit **52** to reduce the output of the electromagnetic induction heating when the measured electric resistance is smaller than a threshold value.

Further, the auxiliary heating plate **69** may be formed of a thin metal member having magnetic characteristic such as iron, nickel, stainless steel, and the like. As long as the material has magnetic characteristic, the auxiliary heating plate **69** may be formed of resin including magnetic powder. Alternatively, the auxiliary heating plate **69** may be formed of the magnetic material, ferrite. The magnetic material, ferrite, promotes the heating of the fixing belt **50** through the magnetic flux generated by the induction current. The magnetic material, ferrite, itself does not generate heat even if the magnetic flux generated by induction current passes through it. The auxiliary heating plate **69** is not limited to a thin plate member.

As shown in FIG. **2**, a shield **76** is arranged on the inner peripheral side of the auxiliary heating plate **69**. The shield **76** has an arc shape similar to the shape of the auxiliary heating plate **69**. The shield **76** is supported by sills (not shown) at the arc-shaped ends thereof. Further, the shield **76** may support the auxiliary heating plate **69**. For example, the shield **76** is made from non-magnetic material such as aluminum, copper, and the like. The shield **76** shields the magnetic flux from the IH coil unit **52**. The shield **76** suppresses an influence on a voltage and the like measured by a thermistor by the magnetic flux.

A nip pad **53** is a pressing unit positioned to press the inner peripheral surface of the fixing belt **50** against the side of the press roller **51**. A nip **54** is formed between the fixing belt **50** and the press roller **51**. The nip pad **53** has a nip forming surface **53***a*, and the nip **54** is formed between the fixing belt **50** pressed by the nip pad **53** and the press roller **51**. Seen in the belt width direction, the nip forming surface **53***a* is curved towards the inner peripheral side of the fixing belt **50** along the outer peripheral surface of the press roller **51**.

For example, the press roller **51** includes a heat-resistant silicon sponge layer and a silicon rubber layer around the core bar. For example, a releasing layer is arranged on the surface of the press roller **51**. The releasing layer is made from fluorine resin such as the PFA resin and the like. The press roller **51** presses the fixing belt **50** through a pressing mechanism. The press roller **51** and the nip pad **53** serve as a pressing unit which presses the fixing belt **50**.

A motor **51***b* is arranged as a driving unit of the fixing belt **50** and the press roller **51**. The motor **51***b* is energized by a motor driving circuit **51***c* that is controlled by the main control circuit **101**. The motor **51***b* is connected to the press roller **51** through a first gear train (not shown). The motor **51***b* is connected to a belt driving member through a second gear train and a one-way clutch (none is shown). The motor **51***b* causes the press roller **51** to rotate in a direction indicated by an arrow q. When the fixing belt **50** is in contact with the press roller **51**, the fixing belt **50** is rotated by the press roller **51** in a direction indicated by an arrow u. When the fixing belt **50** is separated from the press roller **51**, the motor **51***b* directly controls the fixing belt **50** to rotate in the direction indicated by the arrow u. The fixing belt **50** may include a driving unit separately from the driving unit of the press roller **51**.

A center thermistor **61** and an edge thermistor **62** measure a belt temperature. The measured results of the belt temperature are input to the main control circuit **101**. The center thermistor **61** is arranged at a center of the IH coil unit **52** in the belt width direction. The edge thermistor **62** is arranged in a non-paper passing, heating area of the IH coil unit **52** in the belt width direction. The main control circuit **101** controls the IH coil unit **52** in such a manner that the electromagnetic induction heating is stopped when the belt temperature measured by the edge thermistor **62** is greater than a threshold value. The electromagnetic induction heating is stopped when the temperature of the non-paper passing, heating area of the fixing belt **50** rises excessively, and thereby preventing the fixing belt **50** from being damaged.

The main control circuit **101** controls the IH control circuit **67** according to the measured results of the belt temperature by the center thermistor **61** and the edge thermistor **62**. The IH control circuit **67** controls the magnitude of the high frequency current output by the inverter driving circuit **68** under the control of the main control circuit **101**. The fixing belt **50** is maintained within control temperature ranges in accordance with the output of the inverter driving circuit **68**. The IH control circuit **67** includes a CPU, a ROM, and a RAM (none are shown).

A thermostat **63** functions as a safety device of the fixing apparatus **34**. The thermostat **63** is operated when the fixing belt **50** generates heat abnormally and the temperature thereof rises to its shut-off threshold value. With the operation of the thermostat **63**, the current flowing to the IH coil unit **52** is shut off. In this way, the MFP **10** stops driving, and thereby preventing the fixing apparatus **34** from being abnormally heated.

Hereinafter, a control system **110** of the IH coil unit **52** which enables the fixing belt **50** to generate heat is described in detail.

FIG. **5** is a block diagram of the control system **110** which mainly controls the IH coil unit **52** according to the first embodiment.

As shown in FIG. **5**, the control system **110** includes a system control unit **100**, the main control circuit **101**, an IH circuit **120**, and the motor driving circuit **51***c*.

The control system **110** supplies power to the IH coil unit **52** through the IH circuit **120**. The IH circuit **120** includes a rectifier circuit **121**, the IH control circuit **67**, the inverter driving circuit **68**, and a current measurement circuit **122**.

Current is supplied from an AC power supply **111** to the IH circuit **120** through a relay **112**. The IH circuit **120** rectifies the current with the rectifier circuit **121** and then supplies the current to the inverter driving circuit **68**. When the thermostat **63** is cut off, the relay **112** shuts off the current from the AC power supply **111**. The inverter driving circuit **68** includes a drive IC **68***b* of the IGBT element **68***a*. The IH control circuit **67** controls the drive IC **68***b* according to the measured results of the belt temperature by the center thermistor **61** and the edge thermistor **62**. The IH control circuit **67** controls the drive IC **68***b* to control the output of the IGBT element **68***a*. The current measurement circuit **122** sends the measured results output by the IGBT element **68***a* to the IH control circuit **67**. The IH control circuit **67** controls the drive IC **68***b* based on the measured results output from the current measurement circuit **122**, so that the output of the IH coil unit **52** is constant.

The main control circuit **101** acquires a measurement value R (refer to FIG. **7**) from an electric resistance measurement circuit **84***b*. The main control circuit **101** controls the IH coil unit **52** based on the measurement value R. Specifically, the main control circuit **101** determines whether or not the measurement value R is smaller than a threshold value Rt. Then, the main control circuit **101** controls either the continuous driving of the fixing apparatus **34** and the reduction of the output of the IH coil unit **52** based on the determination results. Here, the reduction of output of the IH coil unit **52** includes the stopping of the IH coil unit **52**.

FIG. **6** is a side view of the main portions of the fixing apparatus **34** according to the first embodiment.

As shown in FIG. **6**, the second coil unit **84** includes a second coil **84***a* and the electric resistance measurement circuit **84***b* (electric resistance measurement section). The second coil unit **84** measures whether or not the temperature of the auxiliary heating plate **69** exceeds the Curie point thereof. The second coil **84***a* is arranged separately from the main coil **56**. The second coil **84***a* generates a magnetic field passing through the auxiliary heating plate **69** through energization. For example, the second coil **84***a* includes winding wire of litz wire. The electric resistance measurement circuit **84***b* measures the electric resistance of the second coil **84***a*. The measured result of the electric resistance of the second coil **84***a* is input to the main control circuit **101**.

Hereinafter, it is assumed that an area of the auxiliary heating plate **69** that faces the IH coil unit **52** across the fixing belt **50** and extends along a circumferential direction of the fixing belt **50** (hereinafter referred to as a "belt circumferential direction") is a facing area **69***a*. Further, it is assumed that an end portion **69***c* of the auxiliary heating plate **69** is an end portion of the auxiliary heating plate **69** in the belt circumferential direction, and is an area adjacent to the facing area **69***a*. The end portion **69***c* of the auxiliary heating plate **69** does not face the IH coil unit **52** across the fixing belt **50** in the belt diameter direction.

Further, an end portion **52***c* of the IH coil unit **52** is an end portion in the belt circumferential direction of each of the first core **57** and the second core **58**, and includes a portion protruding to the inner side in the belt diameter direction.

The second coil **84***a* is arranged in an area S1 (refer to FIG. **2**) which faces the auxiliary heating plate **69** but does not face the main coil **56**. Specifically, the area S1 is positioned between the end portion **52***c* of the IH coil unit **52** and the fixing belt **50** in the belt diameter direction. The area S1 ranges from the outer side of the main coil **56** to the end portion **69***c* of the auxiliary heating plate **69** in the belt circumferential direction. The area S1 faces not only the end portion **52***c* of the IH coil unit **52** but also the end portion **69***c* of the auxiliary heating plate **69** across the fixing belt **50** in the belt circumferential direction. One end (end at the inner side) of the area S1 in the belt circumferential direction faces a boundary between the end portion **52***c* of the IH coil unit **52** and the main coil **56** in the belt diameter direction. The other end (an end at the outer side) of the area S1 in the belt width direction faces front ends (arc-shaped both ends) of the end portion **69***c* of the auxiliary heating plate **69** across the fixing belt **50** in the belt diameter direction.

In the present embodiment, the second coil **84***a* is arranged at the outer peripheral side of the fixing belt **50**. The second coil **84***a* faces the end portion **69***c* of the auxiliary heating plate **69** across the fixing belt **50**.

Further, the second coil **84***a* may face the facing area **69***a* of the auxiliary heating plate **69** across the fixing belt **50** in a range where the second coil **84***a* does not face the main coil **56**.

The second coil **84***a* is fixed separately from the fixing belt **50** at a given interval. The second coil **84***a* at least faces the paper passing area in the belt width direction. For example, the second coil **84***a* faces a central portion of the fixing belt **50**.

The size of the second coil **84***a* is smaller than that of the main coil **56**, because the second coil **84***a* is used to generate a magnetic field passing through the auxiliary heating plate **69** that is sufficient for the electric resistance measurement circuit **84***b* to measure the electric resistance of the second coil **84***a*.

When compared to a case in which the size of the second coil **84***a* is identical to or larger than the size of the main coil **56**, it is possible to arrange the second coil **84***a* in the area S1 easier.

The magnetic flux generated by the second coil **84***a* forms a third magnetic path **85** that extends through the heating layer **50***a* of the fixing belt **50**. Further, the magnetic flux generated by the second coil **84***a* forms a fourth magnetic path **86** that extends through the auxiliary heating plate **69** before auxiliary heating plate **69** loses its magnetism due to the temperature thereof exceeding the Curie point thereof. The fourth magnetic path **86** is formed at a position adjacent to the third magnetic path **85** in the belt diameter direction. The fourth magnetic path **86** passes through the auxiliary heating plate **69** and the heating layer **50***a*. The electric resistance of the second coil **84***a* varies in accordance with change of the magnetism of the auxiliary heating plate **69**. That is, the electric resistance of the second coil **84***a* varies according to whether or not the fourth magnetic path **86** is formed.

A weak high frequency current (hereinafter referred to as a "high frequency weak current") flows into the second coil **84***a*, and this current enables the electric resistance measurement circuit **84***b* to measure the electric resistance of the second coil **84***a*. For example, the electric resistance measurement circuit **84***b* is connected at an upstream side and a downstream side of the second coil **84***a* in a current flowing direction, and the aforementioned electric resistance is measured according to the values of current respectively at the upstream side and the downstream side of the second coil **84***a*. Further, it is assumed that the high frequency weak current is weaker than the high frequency current output from the inverter driving circuit **68**.

Next, an example of an operation of the fixing apparatus **34** according to the first embodiment is described with reference to FIG. **7**.

FIG. **7** is a flowchart illustrating an operation of the fixing apparatus **34** according to the first embodiment.

In ACT **100**, the electric resistance measurement circuit **84***b* causes the high frequency weak current to flow into the second coil **84***a*. It is assumed that, for example, the frequency and current of the high frequency weak current are respectively 60 kHz and 10 mA.

In ACT **101**, the electric resistance measurement circuit **84***b* measures the electric resistance of the second coil **84***a*. It is assumed in the present embodiment that the electric resistance of the second coil **84***a* measured by the electric resistance measurement circuit **84***b* is a "measured value R". The main control circuit **101** acquires the measured value R from the electric resistance measurement circuit **84***b*.

Alternatively, the main control circuit **101** may acquire the measured value R from other circuit such as a logic circuit.

In ACT **102**, the main control circuit **101** determines whether or not the measured value R acquired in ACT **101** is smaller than a threshold value Rt (for example, 1"Ω").

By determining whether or not the measured value R is smaller than the threshold value Rt, it is possible to determine the change of magnetism of the auxiliary heating plate **69** for the following reasons.

When the measured value R is greater than the threshold value Rt, the auxiliary heating plate **69** has ferromagnetism because its temperature is lower than the Curie point thereof. When the auxiliary heating plate **69** has ferromagnetism, the magnetic flux generated by the second coil **84***a* forms the third magnetic path **85** and the fourth magnetic path **86**.

On the other hand, when the measured value R is smaller than the threshold value Rt, the auxiliary heating plate **69** has paramagnetism because its temperature is higher than the Curie point thereof. In such a case, the fourth magnetic path **86** is not formed.

Thus, it is possible to estimate the magnetism of the auxiliary heating plate **69** by determining whether or not the measured value R is smaller than the threshold value Rt.

When the main control circuit **101** determines that the measured value R is smaller than the threshold value Rt (YES in ACT **102**), the process proceeds to ACT **104**. When the main control circuit **101** determines that the measured value R is greater than the threshold value Rt (NO in ACT **102**), the process proceeds to ACT **103**.

In ACT **103**, the fixing apparatus **34** continues its driving. For example, when performing a high output driving such as a continuous paper passing and the warming up, the fixing apparatus **34** continues the high output driving.

In ACT **104**, the main control circuit **101** controls the IH coil unit **52** based on the measured value R.

In ACT **105**, the main control circuit **101** determines whether to stop the IH coil unit **52**, based on the measured value R. For example, when the measured value R is smaller than 0.5"Ω", the main control circuit **101** determines to stop the IH coil unit **52**. If it is determined to stop the IH coil unit **52** (YES in ACT **105**), the main control circuit **101** terminates the processing. By stopping the IH coil unit **52**, the main control circuit **101** suppresses the excessive temperature rise of the IGBT element **68***a*. Consequently, the main control circuit **101** prevents the IGBT element **68***a* from being damaged.

If it is determined not to stop the IH coil unit **52** (NO in ACT **105**), the process proceed to ACT **106**.

In ACT **106**, the main control circuit **101** reduces the output of the IH coil unit **52**. For example, the main control circuit **101** reduces the power supplied to the IH coil unit **52**. By reducing the output of the IH coil unit **52**, the main control circuit **101** suppresses the excessive temperature rise of the IGBT element **68***a*. Consequently, the main control circuit **101** prevents the IGBT element **68***a* from being damaged.

In ACT **103**, the fixing apparatus **34** continues its driving when the output of the IH coil unit **52** is reduced.

Hereinafter, the operation of the fixing apparatus **34** during a warming-up operation is described.

As shown in FIG. **2**, the fixing apparatus **34** rotates the fixing belt **50** in the direction indicated by the arrow u during the warming-up operation. By applying the high frequency current through the inverter driving circuit **68**, the IH coil unit **52** generates magnetic flux at the side of the fixing belt **50**.

For example, the fixing belt **50** is rotated in the direction indicated by the arrow u when the fixing belt **50** is separated from the press roller **51** during the warming-up operation. Compared to a case of rotating the fixing belt **50** when the fixing belt **50** is in contact with the press roller **51**, it is possible to avoid the heat of the fixing belt **50** from transferring to the press roller **51**. Consequently, it is possible to shorten the period of the warming up operation.

Alternatively, the fixing belt **50** may be driven to rotate in the direction indicated by the arrow u by rotating the press roller **51** in the direction indicated by the arrow q when the press roller **51** is in contact with the fixing belt **50** at the time of warming up.

As shown in FIG. **4**, the IH coil unit **52** heats the fixing belt **50** through the first magnetic path **81**. The auxiliary heating plate **69** assists the IH coil unit **52** in heating the fixing belt **50** through the second magnetic path **82**. In this way, it enables the rapid warming up of the fixing belt **50**.

As shown in FIG. **2**, the IH control circuit **67** controls the inverter driving circuit **68** according to the measured results of the belt temperatures measured by the center thermistor **61** and the edge thermistor **62**. The inverter driving circuit **68** supplies the high frequency current to the main coil **56**.

Hereinafter, the operations of the fixing apparatus **34** during a fixing operation are described.

After the fixing belt **50** reaches the fixing temperature and the warming-up operation is ended, the press roller **51** is moved to be in contact with the fixing belt **50**. In a state in which the press roller **51** is in contact with the fixing belt **50**, the fixing belt **50** may be driven to rotate in the direction indicated by the arrow u by rotating the press roller **51** in the direction indicated by the arrow q. When a print request is received, the MFP **10** (refer to FIG. **1**) starts a print operation in response. The MFP **10** forms a toner image on the sheet P with the printer unit **18**, and conveys the sheet P to the fixing apparatus **34**.

The MFP **10** causes the sheet P on which the toner image is formed to pass through the nip **54** between the fixing belt **50** that reaches the fixing temperature and the press roller **51**. The fixing apparatus **34** fixes the toner image on the sheet P. During the fixing operation, the IH control circuit **67** controls the IH coil unit **52** to keep the fixing temperature of the fixing belt **50** constant.

Through the fixing operation, the heat of the fixing belt **50** transfers to the sheet P. For example, when a plurality of sheets P continuously passes at a high speed, since the amount of heat transferring to the sheets P is large, the fixing belt **50** having low heat capacity may not be maintained at the fixing temperature. The heat caused by the second magnetic path **82** supplements heating of the fixing belt **50**. As a result, the belt temperature can be maintained at the fixing temperature even in the continuous paper passing at a high speed.

Here, disposing a thermistor which measures the temperature of the IGBT element **68***a* would be useful to prevent the IGBT element **68***a* from being damaged. In such a case, the thermistor would be installed in a case of the inverter driving circuit **68** but not in the IGBT element **68***a* itself. When the thermistor measures a temperature rise of the IGBT element **68***a*, the main control circuit **101** would drive a fan to cool the IGBT element **68***a*. Through the thermistor, the gentle temperature rise of the IGBT element **68***a* may be measured. However, it is difficult for the thermistor to measure a sudden temperature rise. Further, as the thermistor is installed in the case, it is difficult for the thermistor to measure the accurate temperature of the IGBT element **68***a*. The measured temperature of the IGBT element **68***a* by the thermistor may be divergent from the actual temperature of the IGBT element **68***a*. Moreover, the cooling of the IGBT element **68***a* by the fan may not sufficiently cool the internal portion of the IGBT element **68***a*. Thus, the damage of the IGBT element **68***a* cannot be sufficiently prevented by the temperature measurement of the thermistor and the cooling process by the fan.

To the contrary, according to the first embodiment, the electric resistance measurement circuit **84***b* measures the electric resistance of the second coil **84***a*. By measuring the electric resistance of the second coil **84***a*, it is possible to measure not only the gentle temperature rise but also the sudden temperature rise of the IGBT element **68***a* indirectly. Compared with the case of arranging the thermistor described above, it is possible to measure the temperature of the IGBT element **68***a* in real time by measuring the electric resistance of the second coil **84***a*. Furthermore, difference between the measured temperature and the actual temperature of the IGBT element **68***a* would not be an issue in the present embodiment.

Further, the main control circuit **101** acquires the electric resistance (measured value R) of the second coil **84***a* from the electric resistance measurement circuit **84***b*. The main control circuit **101** controls the IH coil unit **52** to weaken the electromagnetic induction heating when the measured value R is smaller than a threshold value. By weakening the electromagnetic induction heating when the measured value R is smaller than the threshold value, it is possible to suppress the excessive temperature rise of the IGBT element **68***a*. Specifically, the main control circuit **101** determines whether or not the measured value R is smaller than the threshold value Rt. If it is determined that the measured value R is smaller than the threshold value Rt, the main control circuit **101** reduces heat generation caused by the IH coil unit **52**. For example, it is possible to suppress the excessive temperature rise of the IGBT element **68***a* by stopping the IH coil unit **52** or by reducing the heat generation by the IH coil unit **52**. As a result, it is possible to prevent the IGBT element **68***a* from being damaged.

Further, as the second coil **84***a* is arranged separately from the main coil **56**, the electric resistance measurement circuit **84***b* can measure the electric resistance of the second coil **84***a*. Thus, the main control circuit **101** can acquire the measured value R.

The second coil **84***a* is arranged in the area **S1** which faces the auxiliary heating plate **69** but does not face the main coil **56**. Compared to a second coil located in an area facing the main coil **56**, it is possible to measure the electric resistance of the second coil **84***a* accurately because the second coil **84***a* is less likely to be affected by a large magnetic force of the main coil **56**.

The second coil **84***a* is arranged to face the end portion **69***c* (a portion adjacent to the facing area **69***a*) of the auxiliary heating plate **69** across the fixing belt **50**. According to this arrangement, the second coil unit **84** can measure the electric resistance of the second coil **84***a* at a location having a temperature change identical to that of the facing area **69***a* (a location having a correlation with the temperature change of the facing area **69***a*).

Further, the second coil **84***a* is arranged to face at least the paper passing area in the belt width direction. According to this arrangement, the second coil unit **84** can measure the electric resistance of the second coil **84***a* separately from the non-paper passing area. Thus, the main control circuit **101** can acquire the measured value R separately from the non-paper passing area.

Second Embodiment

Next, a second embodiment is described with reference to FIG. **8**. Here, components identical to those in the first embodiment are described with the same reference numerals and the description thereof is not provided.

FIG. **8** is a side view of a fixing apparatus **234** according to the second embodiment. Further, FIG. **8** corresponds to the side view of FIG. **6**.

As shown in FIG. **8**, the fixing apparatus **234** according to the second embodiment does not include the second coil **84***a* of the first embodiment. The fixing apparatus **234** according to the second embodiment is different from the first embodiment in that it includes a measurement unit **284** using the main coil **56**. Further, a reference numeral **284***b* indicates the electric resistance measurement circuit in FIG. **8**.

The IH coil unit **52** includes the main coil **56** (coil) which heats the heating layer **50***a* through an electromagnetic induction. The IH coil unit **52** also functions as the measurement unit **284**. The measurement unit **284** generates a magnetic field passing through the auxiliary heating plate **69** through the energization to the main coil **56**. The measurement unit **284** measures the electric resistance of the main coil **56**.

The magnetic flux generated by the main coil **56** forms the first magnetic path **81** and the second magnetic path **82**. The electric resistance of the main coil **56** varies in accordance with the change of magnetism of the auxiliary heating plate **69**.

As the high frequency weak current flows into the main coil **56**, the electric resistance of the main coil **56** can be measured.

The electric resistance measurement circuit **284***b* measures the electric resistance of the main coil **56**. It is assumed in the present embodiment that the electric resistance of the main coil **56** measured by the electric resistance measurement circuit **284***b* is "the measured value R". The main control circuit **101** acquires the measured value R from the electric resistance measurement circuit **284***b*.

The main control circuit **101** determines whether or not the measured value R acquired is smaller than the threshold value Rt (for example, 1"Ω").

By determining whether or not the measured value R is smaller than the threshold value Rt, it is possible to determine the change of magnetism of the auxiliary heating plate **69** for the following reasons.

When the measured value R is greater than the threshold value Rt, the auxiliary heating plate **69** has ferromagnetism because its temperature is lower than the Curie point thereof. When the auxiliary heating plate **69** has ferromagnetism, the magnetic flux generated by the main coil **56** forms the first magnetic path **81** and the second magnetic path **82**.

On the other hand, when the measured value R is smaller than the threshold value Rt, the auxiliary heating plate **69** has paramagnetism because its temperature is higher than the Curie point thereof. In such a case, the second magnetic path **82** is not formed.

Thus, by determining whether or not the measured value R is smaller than the threshold value Rt, it is possible to estimate the magnetism of the auxiliary heating plate **69**.

The main control circuit **101** controls the IH coil unit **52** to reduce the heat generation through the electromagnetic induction heating when the acquired measured value R is smaller than the threshold value Rt.

In accordance with the second embodiment, the same effects as the first embodiment can be obtained.

Further, compared with the case in which the second coil **84***a* faces the end portion **69***c* of the auxiliary heating plate **69** across the fixing belt **50**, it is possible to measure the electric resistance of the main coil **56** at a location facing the facing area **69***a*. Consequently, it is possible to determine the change of magnetism of the facing area **69***a*.

Further, it is possible to measure the electric resistance of the main coil **56** at the timing when the IH coil unit **52** does not generate heat. For example, it is possible to measure the electric resistance of the main coil **56** at a timing between print operations, except for during the continuous paper passing and the warming up (for example, when every 10 papers pass). As a result, the change of magnetism of the facing area **69***a* can be determined between print jobs.

Compared with the case in which the second coil **84***a* is arranged separately from the main coil **56**, the number of components can be reduced and thereby the configuration of the fixing apparatus **234** can be simplified.

Further, the electric resistance of the main coil **56** may be measured at the timing when the IH coil unit **52** generates heat. For example, the electric resistance of the main coil **56** is measured during the continuous paper passing and the warming up. In this way, it is possible to measure the electric resistance of the main coil **56** at the location facing the facing area **69***a* in real time. Consequently, during the continuous paper passing and the warming up, it is possible to determine the change of magnetism of the facing area **69***a* in real time.

Third Embodiment

Next, a third embodiment is described with reference to FIG. **9**. Here, components identical to those in the first embodiment are described with the same reference numerals and the description thereof is not provided.

FIG. **9** is a side view of a fixing apparatus **334** according to the third embodiment. Further, FIG. **9** corresponds to the side view of FIG. **6**.

As shown in FIG. **9**, the fixing apparatus **334** according to the third embodiment does not include the second coil **84***a* of the first embodiment. The fixing apparatus **334** according to the third embodiment is different from the first embodiment in that it includes a second coil **384***a* arranged at the inner peripheral side of the fixing belt **50**. The second coil **384***a* is arranged at the inner side in the diameter direction of the auxiliary heating plate **69**. Further, a reference numeral **384** indicates the second coil unit and a reference numeral **384***b* indicates the electric resistance measurement circuit in FIG. **9**.

The magnetic flux generated by the second coil **384***a* forms a fifth magnetic path **87** that extends through the auxiliary heating plate **69** before the auxiliary heating plate **69** loses its magnetism due to the temperature thereof exceeding the Curie point thereof. The fifth magnetic path **87** passes through the auxiliary heating plate **69** in such a manner that it does not extend to the outer side of the auxiliary heating plate **69** in the belt diameter direction.

The magnetic flux generated by the second coil **384***a* forms a sixth magnetic path **88** that extends through the heating layer **50***a* of the fixing belt **50** when the auxiliary heating plate loses its magnetism due to the temperature thereof exceeding the Curie point thereof. The sixth magnetic path **88** extends to the outer side of the auxiliary heating plate **69** in the belt diameter direction, passing through the heating layer **50***a*. The electric resistance of the second coil **384***a* varies in accordance with the change of magnetism of the auxiliary heating plate **69**.

By causing a high frequency weak current in the second coil **384***a*, it is possible to measure the electric resistance of the second coil **384***a*. The electric resistance measurement circuit **384***b* measures the electric resistance of the second coil **384***a*. It is assumed in the present embodiment that the electric resistance of the second coil **384***a* measured by the electric resistance measurement circuit **384***b* is a "measured value R". The main control circuit **101** acquires the measured value R from the electric resistance measurement circuit **384***b*.

The main control circuit **101** determines whether or not the acquired measured value R is smaller than the threshold value Rt (for example, 1 "Q").

By determining whether or not the measured value R is smaller than the threshold value Rt, it is possible to determine the magnetism of the auxiliary heating plate **69** for the following reasons.

When the measured value R is greater than the threshold value Rt, the auxiliary heating plate **69** has ferromagnetism because its temperature is lower than the Curie point thereof. When the auxiliary heating plate **69** exhibits ferromagnetism, the magnetic flux generated by the second coil **384***a* forms the fifth magnetic path **87**.

On the other hand, when the measured value R is smaller than the threshold value Rt, the auxiliary heating plate **69** has paramagnetism because its temperature is higher than the Curie point thereof. In such a case, the magnetic flux generated by the second coil **384***a* forms the sixth magnetic path **88**, but the fifth magnetic path **87** is not formed.

It is possible to estimate the magnetism of the auxiliary heating plate **69** by determining whether or not the measured value R is smaller than the threshold value Rt.

The main control circuit **101** controls the IH coil unit **52** to reduce the heat generation through the electromagnetic induction heating when the acquired measured value R is smaller than the threshold value Rt.

In accordance with the third embodiment, the same effects as the first embodiment can be obtained.

Further, in the present embodiment, the second coil **384***a* is arranged at the inner side in the belt diameter direction of the auxiliary heating plate **69** on the inner peripheral side of the fixing belt **50**. Compared with a second coil disposed on the outer peripheral side of the fixing belt **50**, it is possible to aggregate the second coil **384***a* as well as the auxiliary heating plate **69** on the inner peripheral side of the fixing belt **50**.

In accordance with the fixing apparatus of at least one embodiment described above, the excessive temperature rise of the IGBT element **68***a* can be suppressed, which can prevent the IGBT element **68***a* from being damaged.

Further, the heating layer **50***a* may be made from the magnetic material such as nickel.

Furthermore, the measurement unit described above is not limited to the electric resistance measurement unit described above. For example, the measurement unit may include a temperature measurement unit which measures the temperature of the auxiliary heating plate **69**. For example, the temperature measurement unit is a temperature sensor. By measuring the temperature of the auxiliary heating plate **69**, it is possible to determine whether or not the temperature of the auxiliary heating plate **69** exceeds the curie point directly. That is, as long as the measurement unit can measure the state of the auxiliary heating plate **69**, no limitation is given to the configuration of the measurement unit.

Further, the present invention is not limited to that the main control circuit **101** indirectly determines whether or not the temperature of the auxiliary heating plate **69** exceeds the Curie point based on the measured results by the electric resistance measurement circuit. For example, the main control circuit **101** may determine whether or not the temperature of the auxiliary heating plate **69** exceeds the Curie point directly based on the measured results by the temperature sensor. That is, as long as the main control circuit **101** can control to reduce the heat generation by the IH coil unit when it is determined that the temperature of the auxiliary heating plate **69** exceeds the Curie point based on the measured results by the measurement unit, no limitation is given to the determination method.

The functions of the fixing apparatuses in the embodiments described above may be realized by a computer. In that case, programs for achieving the functions may be recorded in a computer-readable recording medium, and the programs recorded in the recording medium may be read by a computer system and executed to realize the functions. Further, it is assumed that the "computer system" includes hardware such as an OS, a peripheral machine and the like. Further, the "readable recording medium" refers to a movable medium such as a flexible disc, a magnetic optical disc, an ROM, a CD-ROM and the like, and a storage device such as a hard disk arranged inside the computer system. Further, the "computer-readable recording medium" may store programs dynamically for a short time like a communication line in a case of sending the programs via a network such as the Internet, a telecommunication line such as telephone line and the like, and may also store programs for a certain time like a volatile memory inside a computer system consisting of a server and a client in that case. Further, the programs may be used to realize part of the aforementioned functions, or may also be used to realize the aforementioned functions through a combination with the programs that have already stored in the computer system.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the invention. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the invention. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the invention.

What is claimed is:

1. A fixing apparatus, comprising:

a belt including a ferromagnetic layer;

a ferromagnetic plate disposed inside the belt and having a Curie point that is lower than a Curie point of the ferromagnetic layer;

an induction heater configured to cause heat generation in the ferromagnetic layer and the ferromagnetic plate, the induction heater including a first coil;

a driving circuit configured to output a high frequency current to the first coil, and to change the high frequency current;

a measurement unit configured to output a signal indicative of whether a temperature of the ferromagnetic plate exceeds a predetermined value, the measurement unit including:

a second coil positioned proximate to the ferromagnetic plate, and

an electrical resistance measurement circuit configured to measure an electrical resistance of the second coil, the electrical resistance of the second coil decreasing as the temperature of the second coil increases; and

a controller configured to:

receive the signal output from the measurement unit,

determine whether the temperature of the ferromagnetic plate exceeds the predetermined value based on the signal, and

control the driving circuit to decrease the high frequency current if the temperature of the first coil exceeds the predetermined value.

2. The fixing apparatus according to claim **1**, wherein the predetermined value is the Curie point of the ferromagnetic plate.

3. The fixing apparatus according to claim **1**, wherein the first coil is at a position corresponding to a sheet passing region of the belt in a width direction of the belt.

4. The fixing apparatus according to claim **1**, wherein

the driving circuit comprises switching elements including an insulated gate bipolar transistor (IGBT) and a metal oxide semiconductor field effect transistor (MOSFET), and

the controller decreases the high frequency current by extending an on period of the MOSFET.

5. The fixing apparatus according to claim **1**, wherein the measurement unit is a temperature sensor.

6. A fixing apparatus, comprising:

a belt including a ferromagnetic layer;

a ferromagnetic plate disposed inside the belt and having a Curie point that is lower than a Curie point of the ferromagnetic layer;

an induction heater configured to cause heat generation in the ferromagnetic layer and the ferromagnetic plate, the induction heater including a first coil;

a driving circuit configured to output a high frequency current to the first coil, and to change the high frequency current by switching on and off switching elements;

a measurement unit configured to output a signal indicative of whether a temperature of the ferromagnetic plate exceeds a predetermined value, the measurement unit including:

a second coil positioned proximate to the ferromagnetic plate, and

an electrical resistance measurement circuit configured to measure an electrical resistance of the second coil, the electrical resistance of the second coil decreasing as the temperature of the second coil increases; and

a controller configured to:

receive the signal output from the measurement unit,

determine whether the temperature of the ferromagnetic plate exceeds the predetermined value based on the signal, and

control the driving circuit to decrease the high frequency current if the temperature of the first coil exceeds the predetermined value.

7. The fixing apparatus according to claim **6**, wherein the predetermined value is the Curie point of the ferromagnetic plate.

8. The fixing apparatus according to claim **6**, wherein the first coil is at a position corresponding to a sheet passing region of the belt in a width direction of the belt.

9. The fixing apparatus according to claim **6**, wherein

the driving circuit comprises switching elements including an insulated gate bipolar transistor (IGBT) and a metal oxide semiconductor field effect transistor (MOSFET), and

the controller decreases the high frequency current by extending an on period of the MOSFET.

10. The fixing apparatus according to claim **6**, wherein the measurement unit is a temperature sensor.

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